

What is claimed is:

1. A method of preventing the formation of fractures in a subterranean formation during a drilling operation comprising the steps of:

providing a lightweight drilling fluid that comprises an aqueous fluid and generated gas, the generated gas being generated by a reaction of a gas generating chemical in the aqueous fluid, the gas generating chemical being present in an amount of from about 0.1% to about 10% by weight of the aqueous fluid; and

using the lightweight drilling fluid in the drilling operation to drill a well bore in the subterranean formation.

2. The method of claim 1 wherein the lightweight drilling fluid or the aqueous fluid comprises a gas production rate enhancing agent.

3. The method of claim 2 wherein the gas production rate enhancing agent comprises a copper salt or an iron salt.

4. The method of claim 2 wherein the gas production rate enhancing agent is present in the lightweight drilling fluid or the aqueous fluid in an amount in the range of from about 5% to about 25% by weight of the gas generating chemical.

5. The method of claim 1 wherein the aqueous fluid comprises an activator that comprises a base, a buffer, or an oxidizer.

6. The method of claim 5 wherein the activator comprises an alkali metal hydroxide, an alkaline earth metal hydroxide, an alkaline metal salt of a silicate, potassium phosphate, potassium monohydrogenphosphate, sodium carbonate, sodium bicarbonate, or a mixture thereof.

7. The method of claim 5 wherein the activator comprises an alkaline salt of a peroxide, an alkaline earth metal salt of a peroxide, a persulfate, a perborate, a chlorite, an iodate, a bromate, chloroaurate, arsenate, antimonite, or a molybdate anion.

8. The method of claim 5 wherein the activator comprises ammonium persulfate, sodium persulfate, potassium persulfate, sodium chlorite, sodium chlorate, hydrogen peroxide, sodium perborate, or sodium peroxy carbonate.

9. The method of claim 5 wherein the oxidizer is included in an amount in the range of from about 200% to about 1500% by weight of the gas generating chemical.

10. The method of claim 5 wherein the oxidizer is included in an amount in the range of from about 400% to about 1200% by weight of the gas generating chemical.

11. The method of claim 5 wherein the activator is present in an amount sufficient to maintain the pH of the aqueous fluid in the range of from about 10 to about 14.

12. The method of claim 1 wherein the generated gas is generated in the lightweight drilling fluid during the drilling operation.

13. The method of claim 1 wherein the generated gas comprises nitrogen, ammonia, carbon dioxide, or carbon monoxide.

14. The method of claim 1 wherein the gas generating chemical comprises a hydrazine group, an azo group, hydrazine, azodicarbonamide, azobis(isobutyronitrile), p-toluene sulfonyl hydrazide, p-toluene sulfonyl(semicarbazide), carbohydrazide, p-p' poxybis(benzenesulfonyl hydrazide), an ammonium salt of an organic acid, an ammonium salt of an inorganic acid, hydroxyl amide sulfate, carbamide, or a mixture thereof.

15. The method of claim 1 wherein the gas generating chemical is present in an amount of from about 0.3% to about 8% by weight of the aqueous fluid.

16. The method of claim 1 wherein the gas generating chemical is present in an amount of about 4%.

17. The method of claim 1 wherein the gas is generated by a thermal reaction of the gas generating chemical or by a reaction between the gas generating chemical and an alkaline reagent.

18. The method of claim 1 wherein the lightweight drilling fluid or the aqueous fluid comprises a surfactant.

19. The method of claim 18 wherein the lightweight drilling fluid or the aqueous fluid comprises a mixture of a foaming and a foam stabilizing surfactant.

20. The method of claim 19 wherein the surfactant or the mixture comprises an ethoxylated alcohol ether sulfate surfactant, an alkyl amidopropylbetaine surfactant, an alkene amidopropylbetaine surfactant, an alkyl amidopropyldimethylamine oxide surfactant, an alcohol ether sulfate, cocoamidopropyl betaine, an amine oxide, or an alkene amidopropyldimethylamine oxide surfactant.

21. The method of claim 19 wherein the surfactant or the mixture is present in the lightweight drilling fluid or the aqueous fluid in an amount of from about 0.5% to about 5% by weight of a water component in the lightweight drilling fluid or the aqueous fluid.

22. A method of separating a first fluid and a second fluid in a subterranean formation comprising the steps of:

providing a lightweight spacer fluid that comprises an aqueous fluid and generated gas, the generated gas being generated by a reaction of a gas generating chemical in the aqueous fluid, the gas generating chemical being present in an amount of from about 0.1% to about 10% by weight of the aqueous fluid;

providing a first fluid and a second fluid, the second fluid to be introduced to the subterranean formation after the first fluid;

placing the first fluid into the subterranean formation;

placing the lightweight spacer fluid into the subterranean formation to substantially separate the first fluid from the second fluid; and

placing the second fluid into the subterranean formation.

23. The method of claim 22 wherein the first fluid and the second fluid are chemically incompatible fluids.

24. The method of claim 22 wherein the first fluid is a drilling fluid and the second fluid is a cement slurry.

25. The method of claim 22 wherein the first fluid is a first drilling fluid and the second fluid is a second drilling fluid.

26. The method of claim 22 wherein the spacer fluid or the aqueous fluid comprises a gas production rate enhancing agent.

27. The method of claim 26 wherein the gas production rate enhancing agent comprises a copper salt or an iron salt.

28. The method of claim 22 wherein the aqueous fluid comprises an activator that comprises a base, a buffer, or an oxidizer.

29. The method of claim 28 wherein the activator comprises an alkali metal hydroxide, an alkaline earth metal hydroxide, an alkaline metal salt of a silicate, potassium phosphate, potassium monohydrogenphosphate, sodium carbonate, or sodium bicarbonate, an alkaline salt of a peroxide, an alkaline earth metal salt of a peroxide, a persulfate, a perborate, a chlorite, an iodate, a bromate, chloroaurate, arsenate, antimonite, a molybdate anion, ammonium persulfate, sodium persulfate, potassium

persulfate, sodium chlorite, sodium chlorate, hydrogen peroxide, sodium perborate, or sodium peroxy carbonate.

30. The method of claim 28 wherein the oxidizer is included in an amount in the range of from about 400% to about 1200% by weight of the gas generating chemical.

31. The method of claim 28 wherein the activator is present in an amount sufficient to sustain the pH of the aqueous fluid in the range of from about 10 to about 14.

32. The method of claim 22 wherein the gas generating chemical comprises a hydrazine group, an azo group, hydrazine, azodicarbonamide, azobis(isobutyronitrile), p-toluene sulfonyl hydrazide, p-toluene sulfonyl(semicarbazide, carbohydrazide, p-p' poxybis(benzenesulfonyl hydrazide), an ammonium salt of an organic acid, an ammonium salt of an inorganic acid, hydroxyl amide sulfate, carbamide, or a mixture thereof.

33. The method of claim 22 wherein the lightweight spacer fluid or the aqueous fluid comprises a surfactant or a mixture of a foaming and a foam stabilizing surfactant.

34. The method of claim 33 wherein the surfactant or the mixture comprises an ethoxylated alcohol ether sulfate surfactant, an alkyl amidopropylbetaine surfactant, an alkene amidopropylbetaine surfactant, an alkyl amidopropyldimethylamine oxide surfactant, or an alkene amidopropyldimethylamine oxide surfactant.

35. The method of claim 33 wherein the surfactant or the mixture is present in the lightweight drilling fluid or the aqueous fluid in an amount of from about 0.5% to about 5% by weight of a water component in the lightweight drilling fluid or the aqueous fluid.

36. A method of forming a lightweight well treatment fluid for use in a subterranean formation comprising the steps of:

mixing an aqueous fluid, a surfactant, and a gas generating chemical, the gas generating chemical being present in an amount of from about 0.1% to about 10% by weight of a water component in the aqueous fluid, to form a well treatment fluid; and

allowing the gas generating chemical to react so as to generate a gas in the well treatment fluid to form a lightweight well treatment fluid.

37. The method of claim 36 further comprising using a gas production rate enhancing agent to increase the rate the gas is generated in the well treatment fluid.

38. The method of claim 37 wherein the gas production rate enhancing agent comprises a copper salt or an iron salt.

39. The method of claim 36 wherein the gas generating chemical comprises a hydrazine group, an azo group, hydrazine, azodicarbonamide, azobis(isobutyronitrile), p-toluene sulfonyl hydrazide, p-toluene sulfonyl(semicarbazide, carbohydrazide, p-p' poxybis(benzenesulfonyl hydrazide), an ammonium salt of an organic acid, an ammonium salt of an inorganic acid, hydroxyl amide sulfate, carbamide, or a mixture thereof.

40. The method of claim 36 wherein the gas generating chemical is present in an amount of from about 0.3% to about 8% by weight of the aqueous fluid.

41. The method of claim 36 wherein the surfactant comprises a mixture of a foaming and a foam stabilizing surfactant.

42. The method of claim 36 wherein the surfactant comprises an ethoxylated alcohol ether sulfate surfactant, an alkyl amidopropylbetaine surfactant, an alkene amidopropylbetaine surfactant, an alkyl amidopropyldimethylamine oxide surfactant, or an alkene amidopropyldimethylamine oxide surfactant.

43. A method of enhancing the permeability of a subterranean zone comprising the steps of:

allowing a gas generating chemical to react in an aqueous fluid to generate generated gas;

adding the generated gas to an aqueous acidic well treatment fluid to produce a foamed aqueous acidic well treatment fluid; and

using the foamed aqueous acidic well treatment fluid in a treatment to enhance the permeability of a subterranean zone.

44. The method of claim 43 wherein the generated gas is produced by a reaction of the gas generating chemical and an activator in the aqueous fluid, the activator comprising a base, a buffer, or an oxidizer.

45. The method of claim 44 wherein the activator is capable of increasing the pH of the aqueous fluid to a range of about 10 to about 14.

46. The method of claim 43 wherein the aqueous fluid comprises a water component.

47. The method of claim 46 wherein the gas generating chemical is present in the aqueous fluid in an amount in the range of from about 10% to about 100% by weight of a water component therein.

48. The method of claim 44 wherein the activator is present in an amount of about 400% to about 1200% by weight of the gas generating chemical in the aqueous fluid.

49. The method of claim 43 wherein the generated gas is added to the aqueous acidic well treatment fluid as the aqueous acidic well treatment fluid is being pumped into a well bore penetrating or neighboring the subterranean zone.

50. The method of claim 43 wherein the aqueous acidic well treatment fluid comprises a surfactant.

51. The method of claim 50 wherein the surfactant comprises a mixture of foaming and foam stabilizing surfactants.

52. The method of claim 50 wherein the surfactant comprises a linear alcohol ethoxylate, a betaine, or a nonylphenol ethoxylate.

53. The method of claim 50 wherein the surfactant is present in an amount of from about 1% to about 5% by weight of a water component in the foamed aqueous acidic well treatment fluid.

54. The method of claim 43 wherein the aqueous acidic well treatment fluid comprises an acid component that comprises hydrochloric acid, hydrofluoric acid, fluoroboric acid, formic acid, acetic acid, citric acid, lactic acid, thioglycolic acid, glycolic acid, or a mixture thereof.

55. The method of claim 54 wherein the acid component is present in the aqueous acidic well treatment fluid in an amount up to about 30% by weight of the aqueous acidic well treatment fluid.



56. A method of enhancing the recovery of spent acid from a subterranean zone comprising the step of contacting the spent acid with a foamed aqueous acidic well treatment fluid in the subterranean zone.

57. The method of claim 56 wherein the foamed aqueous acidic well treatment fluid comprises an acid component that comprises hydrochloric acid, hydrofluoric acid, fluoroboric acid, formic acid, acetic acid, citric acid, lactic acid, thioglycolic acid, glycolic acid, or a mixture thereof.

58. The method of claim 57 wherein the acid component is present in the aqueous acidic well treatment fluid in an amount up to about 30% by weight of the aqueous acidic well treatment fluid.

59. The method of claim 56 wherein the spent acid results from an acid stimulation treatment in the subterranean zone.

60. The method of claim 56 wherein the foamed aqueous acidic well treatment fluid comprises gas generated by a reaction of a gas generating chemical.

61. The method of claim 56 wherein the foamed aqueous acidic well treatment fluid comprises a surfactant.

62. A lightweight drilling fluid that comprises an aqueous fluid and a gas generated by a reaction of a gas generating chemical in the aqueous fluid, the gas generating chemical being present in an amount of from about 0.1% to about 10% by weight of the aqueous fluid.

63. The composition of claim 62 wherein the lightweight drilling fluid or the aqueous fluid comprises a gas production rate enhancing agent.

64. The composition of claim 63 wherein the gas production rate enhancing agent comprises a copper salt or an iron salt.

65. The composition of claim 63 wherein the gas production rate enhancing agent is present in the lightweight drilling fluid or the aqueous fluid in an amount in the range of from about 5% to about 25% by weight of the gas generating chemical.

66. The composition of claim 62 wherein the aqueous fluid comprises an activator that comprises a base, a buffer, or an oxidizer.

67. The composition of claim 66 wherein the activator comprises an alkali metal hydroxide, an alkaline earth metal hydroxide, an alkaline metal salt of a silicate, potassium phosphate, potassium monohydrogenphosphate, sodium carbonate, or sodium bicarbonate, an alkaline salt of a peroxide, an alkaline earth metal salt of a peroxide, a persulfate, a perborate, a chlorite, an iodate, a bromate, chloroaurate, arsenate, antimonite, a molybdate anion, ammonium persulfate, sodium persulfate, potassium persulfate, sodium chlorite, sodium chlorate, hydrogen peroxide, sodium perborate, or sodium peroxy carbonate.

68. The composition of claim 66 wherein the oxidizer is included in an amount in the range of from about 200% to about 1500% by weight of the gas generating chemical.

69. The composition of claim 66 wherein the oxidizer is included in an amount in the range of from about 400% to about 1200% by weight of the gas generating chemical.

70. The composition of claim 66 wherein the activator is present in an amount sufficient to maintain the pH of the aqueous fluid in the range of from about 10 to about 14.

71. The composition of claim 62 wherein the gas comprises nitrogen, ammonia, carbon dioxide, or carbon monoxide.

72. The composition of claim 62 wherein the gas generating chemical comprises a hydrazine group, an azo group, hydrazine, azodicarbonamide, azobis(isobutyronitrile), p-toluene sulfonyl hydrazide, p-toluene sulfonyl(semicarbazide, carbohydrazide, p-p' poxybis(benzenesulfonyl hydrazide), an ammonium salt of an organic acid, an ammonium salt of an inorganic acid, hydroxyl amide sulfate, carbamide, or a mixture thereof.

73. The composition of claim 62 wherein the gas generating chemical is present in an amount of from about 0.3% to about 8% by weight of the aqueous fluid.

74. The composition of claim 62 wherein the gas generating chemical is present in an amount of about 4%.

75. The composition of claim 62 wherein the gas is generated by a thermal reaction of the gas generating chemical or by a reaction between the gas generating chemical and an alkaline reagent.

76. The composition of claim 62 wherein the lightweight drilling fluid or the aqueous fluid comprises a surfactant.

77. The composition of claim 62 wherein the lightweight drilling fluid or the aqueous fluid comprises a mixture of a foaming and a foam stabilizing surfactant.

78. The composition of claim 76 wherein the surfactant comprises an ethoxylated alcohol ether sulfate surfactant, an alkyl amidopropylbetaine surfactant, an alkene amidopropylbetaine surfactant, an alkyl amidopropyldimethylamine oxide surfactant, or an alkene amidopropyldimethylamine oxide surfactant.

79. The composition of claim 76 wherein the surfactant is present in the lightweight drilling fluid or the aqueous fluid in an amount of from about 0.5% to about 5% by weight of a water component in the lightweight drilling fluid or the aqueous fluid.

80. A lightweight spacer fluid that comprises an aqueous fluid and a gas generated by a reaction of a gas generating chemical in the aqueous fluid, the gas generating chemical being present in an amount of from about 0.1% to about 10% by weight of the aqueous fluid.

81. The composition of claim 80 wherein the spacer fluid or the aqueous fluid comprises a gas production rate enhancing agent.

82. The composition of claim 81 wherein the gas production rate enhancing agent comprises a copper salt or an iron salt.

83. The composition of claim 80 wherein the gas generating chemical comprises a hydrazine group, an azo group, hydrazine, azodicarbonamide, azobis(isobutyronitrile), p-toluene sulfonyl hydrazide, p-toluene sulfonyl(semicarbazide, carbohydrazide, p-p' poxybis(benzenesulfonyl hydrazide), an ammonium salt of an organic acid, an ammonium salt of an inorganic acid, hydroxyl amide sulfate, carbamide, or a mixture thereof.

84. The composition of claim 80 wherein the spacer fluid or the aqueous fluid comprises a surfactant or a mixture of a foaming and a foam stabilizing surfactant.

85. The composition of claim 84 wherein the surfactant or the mixture comprises an ethoxylated alcohol ether sulfate surfactant, an alkyl amidopropylbetaine surfactant, an alkene amidopropylbetaine surfactant, an alkyl amidopropyldimethylamine oxide surfactant, or an alkene amidopropyldimethylamine oxide surfactant.

86. The composition of claim 84 wherein the surfactant or the mixture is present in the lightweight drilling fluid or the aqueous fluid in an amount of from about 0.5% to about 5% by weight of a water component in the lightweight drilling fluid or the aqueous fluid.

87. A foamed aqueous acidic well treatment fluid that comprises an acid component and generated gas, the generated gas being a product of a reaction of a gas generating chemical in an aqueous fluid.

88. The composition of claim 87 wherein the aqueous fluid comprises an activator capable of reacting with the gas generating chemical to produce the generated gas, the activator comprising a base, a buffer, or an oxidizer.

89. The composition of claim 87 wherein the aqueous fluid comprises a water component.

90. The composition of claim 89 wherein the gas generating chemical is present in the aqueous fluid in an amount in the range of from about 10% to about 100% by weight of the water component therein.

91. The composition of claim 88 wherein the activator is present in an amount of about 400% to about 1200% by weight of the gas generating chemical in the aqueous fluid.

92. The composition of claim 87 wherein the aqueous acidic well treatment fluid or the aqueous fluid comprises a surfactant.

93. The composition of claim 92 wherein the surfactant comprises a mixture of foaming and foam stabilizing surfactants.

94. The composition of claim 92 wherein the surfactant comprises a linear alcohol ethoxylate, a betaine, or a nonylphenol ethoxylate.

95. The composition of claim 92 wherein the surfactant is present in an amount of from about 1% to about 5% by weight of a water component in the foamed aqueous acidic well treatment fluid.

96. The composition of claim 87 wherein the acid component comprises hydrochloric acid, hydrofluoric acid, fluoroboric acid, formic acid, acetic acid, citric acid, lactic acid, thioglycolic acid, glycolic acid, or a mixture thereof.

97. The composition of claim 87 wherein the acid component is present in the aqueous acidic well treatment fluid in an amount up to about 30% by weight of the aqueous acidic well treatment fluid.

98. A method of making a foamed aqueous acidic well treatment fluid comprising the steps of:

reacting a gas generating chemical in an aqueous fluid to generate some generated gas; and

incorporating the generated gas into an aqueous acidic well treatment fluid to produce a foamed aqueous acidic well treatment fluid.

99. The method of claim 98 wherein the generated gas is incorporated into the aqueous acidic well treatment fluid as the fluid is being pumped into a well bore penetrating a subterranean formation.

100. A method of making a foamed well fluid that comprises a gas comprising the steps of:

combining an aqueous fluid, a surfactant, and a gas generating chemical, the gas generating chemical being present in an amount in the range of from about .1% to 100% of a water component in the aqueous well fluid; and

allowing the gas generating chemical to react so that gas is generated in the aqueous fluid to form a foamed well fluid.

101. The method of claim 100 wherein the aqueous fluid comprises a gas production rate enhancing agent.

102. The method of claim 100 wherein the aqueous fluid comprises an activator that comprises a base, a buffer, or an oxidizer.

103. The method of claim 102 wherein the activator is present in an amount sufficient to maintain the pH of the aqueous fluid in the range of from about 10 to about 14.

104. The method of claim 100 wherein the gas generating chemical comprises a hydrazine group, an azo group, hydrazine, azodicarbonamide, azobis(isobutyronitrile), p-toluene sulfonyl hydrazide, p-toluene sulfonyl(semicarbazide, carbohydrazide, p-p' poxybis(benzenesulfonyl hydrazide), an ammonium salt of an organic acid, an ammonium salt of an inorganic acid, hydroxyl amide sulfate, carbamide, or a mixture thereof.

105. The method of claim 100 wherein the gas generating chemical is present in an amount of from about 0.3% to about 8% by weight of the aqueous fluid.

106. The method of claim 100 wherein the surfactant comprises an ethoxylated alcohol ether sulfate surfactant, an alkyl amidopropylbetaine surfactant, an alkene amidopropylbetaine surfactant, an alkyl amidopropyldimethylamine oxide surfactant, an alcohol ether sulfate, cocoamidopropyl betaine, an amine oxide, or an alkene amidopropyldimethylamine oxide surfactant.

107. The method of claim 100 further comprising the step of using the foamed well fluid in a subterranean operation.

108. The method of claim 107 wherein the subterranean operation comprises drilling a well bore.

109. The method of claim 107 wherein the subterranean operation involves using the foamed well fluid as a spacer fluid to separate a first well fluid and a second well fluid.

110. The method of claim 109 wherein the first well fluid and the second well fluid are chemically incompatible fluids.

111. The method of claim 100 wherein the foamed well fluid is acidic.

112. A foamed well fluid made by the method of claim 100.